THESIS PROPOSAL:

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Title :
Search for new physics with three-body decays of beauty mesons to charmless final states at LHCb

Topic :

Hadronic decays of B mesons allow a large range of physical observables to be studied, including branching ratios, direct CP asymmetries, the pattern of strong and weak phases between contributing diagrams, and the angles of the unitarity triangle. These studies provide information on the dynamics of both strong and weak interactions. The typical branching fraction for the modes in question is below 10^{-5}, and so to study them requires a large sample of data and the use of sophisticated methods to reject background. The B-factories, *BABAR* and Belle, produced a large number of results on the decays of B^0_d ($\bar{b}d$) mesons into charmless three-body final states, mostly during the 2000s. Since the future B-factory experiment Belle II has yet to begin taking physics data, LHCb is currently the only flavour physics experiment active in this area. Moreover, LHCb has the advantage of being able to study decays of other related particles: the B^0_s ($\bar{b}s$) meson and beauty baryons (bqq).

The LHCb group at LPNHE has developed considerable experience in this area, with some of the group's members having worked previously on such analyses at *BABAR*. This expertise is now being applied to data from the LHCb experiment: the LHCb collaboration, with the active participation of the LPNHE group, has already measured branching fractions for the set of modes $B^0_{d,s} \rightarrow K_S\, h^+\, h'^-$ (where h and h' are pions or kaons) with the 3 fb^{-1} of data collected during the LHC Run 1. The results with B^0_d have allowed the measurements from the B factories to be confirmed, and added first measurements for those with B^0_s. These results were the basis of a thesis project at LPNHE that was defended successfully in 2016.

The current phase of this work consists of an amplitude analysis that uses information from across the full phase space of the decay, known as the Dalitz Plot, to study the contributions from intermediate resonances. This technically demanding method is based on using the interference between different resonances to resolve ambiguities on their relative phases, which allows the CP asymmetry of each of the contributing amplitudes to be determined. This is a necessary ingredient to search for physics beyond the Standard Model in the "penguin" modes ($b \rightarrow q\bar{q}s$ and $b \rightarrow s\bar{s}d$). The candidate will contribute to this work for $B^0_{d,s} \rightarrow K_S\, h^+\, h'^-$, with the possibility of extending the same approach to other decay modes.

At the time of writing, LHCb has already recorded 6 fb^{-1} of data, of which 3 fb^{-1} were taken at a centre-of-mass energy of 13 TeV. This is expected to rise to around 8 fb^{-1} by the end of 2018 (corresponding to the end of the LHC Run 2). The thesis analysis will be able to make use of the full Run 1+2 data sample. As well as working on the analysis, the PhD student will contribute to data-taking at LHCb, developing technical skills and experience with detector operations.

In order to take data at an increased luminosity in future LHC runs, and thereby increase its discovery potential, the LHCb collaboration is preparing an upgrade of the detector. The LHCb group is working on one of the new components of this detector: the Scintillating Fibre Tracker. The student

will contribute to this activity as well, working on real-time signal processing and on improving the efficiency of track reconstruction algorithms.

This thesis topic will allow the candidate to be involved in an important and developing area of research, within a dynamic collaboration. At the end of their thesis, the candidate will be familiar with sophisticated particle physics analysis tools, and with the analysis of a particle that is central to flavour physics: the B meson. As well as yielding progress in B physics itself, the work will have broader impact through its sensitivity to new physics beyond the Standard Model.

Place of work : LPNHE (Paris), with regular short trips to CERN

Documentation :

Web page of the LHCb experiment (http://lhcb.web.cern.ch/lhcb/)

Web page of LPNHE (http://www-lpnhep.in2p3.fr/)

LHCb publications on the ratios of branching fractions of the modes $B^0_{d,s} \to K_S\, h^+\, h^-$, with 1 fb^{-1} of data (JHEP10(2013)143, http://arxiv.org/abs/1307.7648) and with 3 fb^{-1} of data (https://arxiv.org/abs/1707.01665).

Thesis of Louis Henry, a previous LPNHE-LHCb student : Search for new physics in charmless three-body B-meson decats at LHCb (https://tel.archives-ouvertes.fr/tel-01412761)

HDR thesis of Eli Ben-Haim: Amplitude analyses and three-body charmless B decays (http://www.slac.stanford.edu/~benhaim/divers/HDR.pdf)